COMBINED VOLUME AND SELECTIVITY CONTROL DEVICE

Filed June 29, 1942

[Electrical diagram and graphs with labels for resistance and frequency response]
My present invention relates to control devices for radio receivers, and more particularly to a radio receiver adapted to have its output level and selectivity concurrently controlled.

One of the main objects of my present invention is to provide a novel and simplified method of, and means for, concurrently adjusting the radio frequency amplifier gain and selectivity of a radio receiver.

Another important object of my invention is to provide in the tuned radio frequency amplifier section of a radio receiver a device for simultaneously controlling the gain of one amplifier stage and the shape of the response curve of another amplifier stage.

Another important object of this invention is to provide in association with at least two cascaded tuned radio frequency amplifiers a volume control device capable of adjusting the gain of a later amplifier, and adjustment of the aforementioned gain causing a second device to be operative to alter the selectivity of an earlier amplifier.

Another object of the invention is to provide across the tuned input circuit of a radio frequency amplifier of a radio receiver a selectivity control diode whose conductivity is a function of the adjustment of the volume control device of a tuned radio frequency amplifier which follows the first mentioned amplifier.

Still other objects of the invention are to improve generally the simplicity and efficiency of volume-selectivity control devices for high frequency receiving equipment, and more especially to provide such control device in a readily manufacturable and economical manner.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows a circuit diagram of a portion of a radio receiver embodying the invention.

Fig. 2 shows the effect of the invention on the selectivity of the controlled amplifier.

Fig. 3 graphically shows the effect of the selectivity control diode on the impedance of the resonant input circuit of the controlled amplifier.

Referring now to Fig. 1, there is shown a pair of cascaded radio frequency amplifiers designated by numerals 1 and 2. While each of these tubes is shown as of the pentode type, it is to be understood that any other types of tubes may be employed. The tube 1 may be a 6AB7 type of tube, while tube 2 may be a 6SJ7. However, this invention is in no way restricted to the nature of the tubes to be employed. The signal input grid 3 of tube 1 is shown connected to a high frequency signal pick-up device 4 which has the high potential side thereof connected to grid 3 through a radio frequency coil 5 arranged in series with a coupling condenser 6. The adjustable tuning condenser 7 is connected between the junction of coil 5 and condenser 6 and ground. Hence network 5—7 functions as the tunable input circuit of the amplifier 1.

The signal pick-up device 4 preferably has an impedance of the order of 100 ohms, although it is to be understood that this value is purely illustrative. The coil 5 preferably has a voltage step-up ratio of about 20, but here, again, this constant is merely given by way of illustration. The plate 8 of tube 1 is connected to an intermediate point on the coil 9 of the following tuned circuit. This is done to increase the selectivity of the tuned circuit. The coil 9 is shunted by the adjustable condenser 10. Network 9—10 is, of course, tuned to the same high frequency to which circuit 5—7 is tuned. The low alternating potential side of the network 9—10 is connected to ground for high frequency currents. The screen grid electrode of tube 1 is connected by lead 11 to the low alternating potential end of coil 9, and both the plate and screen grid of tube 1 will be connected to the plus 250 volt terminal of the direct current source of the receiving system.

The cathode of tube 1 may be connected to ground through the usual bypassed biasing resistor 12, the grid 3 being connected to ground through the grid return resistor 13. The following amplifier 2 has its control grid 14 coupled to the high alternating potential side of its resonant input circuit 15—16 through the coupling condenser 15. The control grid 14 is returned to ground through the grid return resistor 15. The plate and screen grid of tube 2, as in the case of tube 1, are connected respectively to an intermediate point and the lower end of the following coil 17. The adjustable tuning condenser 10' shunts coil 19, and tunes the latter to the same high frequency as the preceding high frequency circuits are tuned to. The lower end of coil 19 will also be connected to the plus 250 volt terminal of the energizing current source of the receiver.

The voltage supply resistor, which is con-
connected in the usual manner across the direct current source of a receiving system, is shown as comprising four sections designated by the numerals 17, 18, 19 and 20. The left hand terminal of resistor 20 is established at ground potential, while the right hand end of resistor 17 is connected to provide the plus 250 volt potential point referred to previously. The cathode 21 of tube 2 is connected by lead 22 and an adjustable tap 23 to section 18 of the voltage supply potentiometer. Thus, adjustable tap 23 constitutes the volume control device which is adjusted between minimum and maximum volume points as indicated in Fig. 1. When the tap 23 is adjusted to the right hand end of resistor section 18, the bias of the control grid 14 of tube 2 is a maximum, and accordingly the gain of tube 2 is a minimum. This results in the volume output level of the receiving system being a minimum. Conversely, when tap 23 is adjusted to the left hand end of resistor section 18, the negative bias on grid 14 is a minimum with the result that the receiver output level is a maximum.

The selectivity control device may consist of a diode 30. This can be a 6H6 type tube whose anodes are strapped together, and are connected by lead 31 to the high alternating potential side of the tuning condenser 7. The cathodes of tube 30 are connected together, and the lead 32 connects them to the junction of resistor sections 20 and 19. The said junction is bypassed to ground by a condenser 40 having a magnitude of approximately 0.5 micro-microfarads (m.m.f.). This magnitude is purely illustrative. Merely by way of illustration, it is also pointed out that resistor section 17 may have a magnitude of 47,000 ohms; resistor section 18 may have a magnitude of 5,000; resistor section 19 may have a magnitude of 1,000 ohms; and section 20 may have a magnitude of 150 ohms.

It will now be seen that the diode 30 acts as a shunt impedance across the tuned input circuit 5—7. The delay bias on diode 30 varies inversely with the negative bias on grid 14. It is to be understood that the signal pick-up device 4 includes within it a conductive path to ground so that the diode anode returns to ground. In the absence of signal energy the potential difference between the anode and cathode of the diode 30 depends upon the potential of the junction of resistor sections 20 and 18. The potential of that junction point, in turn, depends upon the adjustment of tap 23 on resistor section 18. This will be obvious from the fact that the space current of amplifier 2 flows through lead 22 and tap 23 to the voltage supply network.

Generally speaking, the resonance curve of input circuit 5—7 will assume the shape shown by the full line curve of Fig. 2 when weak signals are received. This can be readily seen from the fact that for weak signal reception the adjustable tap 23 will be adjusted along resistor section 18 to the maximum setting. In that adjustment of the volume control tap 23 the effective negative bias on grid 14 of amplifier 2 is a minimum with the result that the space current flow through lead 22 is a maximum. Hence, there will be an increase of current flow through the resistor sections 19 and 20 to ground. This means that the cathode of diode 30 becomes increasingly positive with respect to the diode anode. Therefore, the delay bias on the diode anode is a maximum. For example, let it be assumed that it is approximately 1.5 volts in that condition. The equivalent series impedance of the diode 30 is the reciprocal of the shunt impedance, and, therefore, there is minimum damping of input circuit 5—7. This sharp resonance curve is desirable as signal reception for the reason that interference effects are more than discriminated against. Noises are readily reduced when the input circuit 5—7 has high selectivity.

Conversely, when the received signal strength is of a high level, the volume control tap 23 is adjusted to the minimum volume setting of resistor section 18. This causes a reduced cathode current flow through lead 22. The effective delay bias of diode 30 is reduced. Fig. 2 shows the round top resonance curve shown in dotted line which results for strong signal reception when the effective delay bias of —0.15 volts is produced on the diode 30.

Fig. 3 shows how the impedance of the tuned circuit 5—7 decreases towards 25,000 ohms (equals QoL, where Q = 1) as a minimum as the delay bias of diode 30 is decreased. It will be understood that when the delay bias of diode 30 is a minimum, then the received signal amplitude will be sufficient to override the minimum bias and render diode 30 conductive. When diode 30 is conductive it has a minimum impedance, and, therefore, presents maximum equivalent series damping impedance to the tuned circuit 5—7. The broadened resonance curve is therefore produced.

At maximum setting of tap 23 the diode 30 looks like a shunt capacitor across capacitor 7, because it is non-conductive. The circuit impedance of 5—7 is equal to QoL. When the diode becomes conductive it acts like a variable resistor shunted across the tuned circuit. The more conductive the diode becomes, the lower the tuned circuit impedance because the Q of the tuned circuit is lowered. When receiving weak signals the delay bias on diode 30 is minus 1.5 volts. This means that a weak signal must develop at least a peak voltage of 1.5 volts across coil 5. With an antenna gain of 20 in the tuned circuit, the weak signal must be equal to approximately 53,000 microvolts which is considered a strong signal because one microvolt will give full receiver output.

It will, therefore, be appreciated that concurrently with the adjustment of the volume control instrumentality there is secured a simultaneous change in the selectivity and attenuation of the input circuit 5—7. For strong signal reception, the volume control device is adjusted to increase the gain of amplifier 2. Simultaneously the input circuit 5—7 is dampened to increase the attenuation of signals and decrease selectivity. Selectivity may be reduced in that case, because the signal level will be sufficient to override any interference or noise effects. The reverse is true in the case of weak signal reception, because in that case the gain of amplifier 2 is increased with concurrent increase in selectivity of input circuit 5—7.

It is to be understood that the circuits 5—7, 9—10, and 9—10' are each tuned to the common carrier frequency of the signals. Furthermore, the volume control device may be located in the intermediate frequency amplifier of a heterodyne receiver, or it may be even located in the cathode circuit of an audio frequency amplifier. The essential requirement is that the diode 30 have its effective delay bias varied in accordance with variations in gain of the amplifier subjected to volume control action. Further, it is essential to have the delay bias on diode 30 high.
enough to permit maximum sensitivity on weak signals, and to prevent diode 30 from becoming conductive. It is, also, pointed out that a plurality of selectivity control diodes may be inserted across cascaded resonant selective circuits. It will now be seen that I have provided a novel method of changing the input selectivity when the volume control is adjusted from setting to setting. In this way I can decrease the time constant of the input circuit 5–1 so that the receiver will quickly recover after being subjected to excessive signal input voltages. It will also be noted that it is possible to increase the radio frequency attenuation over the amount controlled by volume control 23. With large signal input voltage up to 250 volts the diode 30 acts to prevent this input voltage from building up to a value equal to Q times 250 volts by making Q drop to unity. Then, the 280 volts is dropped across the reactance of coil 5 which limits the current taken by diode 30.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is not limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a high frequency receiving system, a first amplifier tube provided with a selector circuit, a diode connected in shunt across said selector circuit, at least a second amplifier tube provided with input electrodes and output electrodes, a second selector circuit coupling the first amplifier tube to the input electrodes of the second amplifier tube, a direct current voltage energizing network common to the space current paths of said diode and second amplifier tube, and means connected to said energizing network and located in the space current path of said second amplifier tube for regulating the space current flow of said second amplifier tube between predetermined maximum and minimum values whereby the second tube amplification is varied over a relatively wide range thereby automatically to adjust the conductivity of said diode over said range.

2. In a high frequency system, a first electron discharge device provided with a resonant circuit, means having variable conductivity operatively connected to said resonant circuit for controlling the selectivity thereof, a second electron discharge device having input electrodes and output electrodes, means coupling the input electrodes of said second device to said first device, a variable resistor arranged in the space current path of the second device for adjusting the space current flow of the second device over a relatively wide range thereby to provide a gain control resistor causes changes in conductivity of said variable conductivity means thereby to vary the selectivity of said resonant circuit.

3. In a high frequency receiving system, a first amplifier tube provided with a selector circuit, a diode connected in shunt across said selector circuit, at least a second amplifier tube provided with input and output electrodes, a direct current voltage energizing network common to the space current paths of said diode and second amplifi

4. In combination with a selector input circuit, a device of unidirectional conductivity operatively associated with said selector circuit to control the selectivity thereof, an amplifier tube following said input circuit, and a potentiometer including a manually adjustable element common to the space current path of said amplifier tube and said device of unidirectional conductivity for rendering the conductivity of such device dependent upon relatively wide changes in space current of said amplifier tube.

5. In a high frequency receiving system, a first amplifier tube provided with a selector circuit, a diode connected in shunt across said selector circuit, at least a second amplifier tube provided with input electrodes and output electrodes, a second selector circuit coupling the first amplifier tube to the input electrodes of the second amplifier tube, a direct current voltage energizing network common to the space current paths of said diode and second amplifier tube, and an adjustable potentiometer connected in circuit with the energizing network and located in the space current path of the second amplifier tube for regulating over a relatively wide range the space current flow of said second amplifier tube and its amplification thereby automatically to adjust the conductivity of said diode.

6. In a high frequency system, a first electron discharge device provided with a resonant circuit, a control electronic device having variable conductivity operatively connected to said resonant circuit for controlling the selectivity thereof, said control electronic device acting like a capacitor when non-conductive, a second electron discharge device having input electrodes and output electrodes, means coupling the input electrodes of said second device to said first device, a potentiometer including a manually adjustable element arranged in the space current path of the second device for adjusting the space current flow of the second device over a relatively wide range thereby to provide a gain control instrumentality, and said control electronic device of variable conductivity being operatively connected to said space current path of the second device so that adjustment of said gain control instrumentality causes changes in conductivity of said control electronic device thereby to vary the selectivity of said resonant circuit.

7. In combination, a first tube provided with a resonant circuit, a diode operatively connected to said resonant circuit for controlling the selectivity thereof, a second tube having input electrodes and output electrodes, means coupling the input electrodes of said second tube to said first tube, means arranged in the space current path of the second tube for adjusting the space current flow of the second tube between relatively widely spaced minimum and maximum values whereby to provide a volume control instrumentality, and said diode being operatively connected to said space current path of the second tube so that adjustment of said volume control instrumentality causes changes in conductivity of said diode thereby to vary the selectivity of said resonant circuit.

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